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IERI Procedia 7 (2014) 35 – 41
Procedia IERI
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2013 International Conference on Applied Computing, Computer Science, and Computer Engineering

# Increasing Immersiveness into a 3D Virtual World: Motion-Tracking and Natural Navigation in vAcademia

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**Abstract**

In this paper, we present a project aiming at integrating immersive virtual reality technologies into a three-dimensional virtual world. We use an educational platform vAcademia as a test bed for the project, and focus on improving the learning process and, subsequently – the outcomes. We aim at increasing the immersiveness of 3D virtual world experience by applying motion tracking for controlling the avatar and two technologies for natural navigation: immersive projection and head-mounted display. In addition, we propose the major types of learning scenarios for the use of the designed systems.


Selection and peer review under responsibility of Information Engineering Research Institute

*Keywords:*3D virtual worlds; motion capture; Kinect; immersive projection technology; CAVE; head-mounted displays; Oculus Rift; vAcademia.

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Selection and peer review under responsibility of Information Engineering Research Institute
doi:10.1016/j.ieri.2014.08.007

## 1. Introduction

Three-dimensional Virtual Worlds provide both opportunities and challenges for education, and many topics in this area need further research[1,2]. Despite the repeated positive conclusions, 3D VWs have not become widely used, and researchers often report that their studies have experimental nature. The most common problems with applying 3D VWs in the everyday teaching are steep learning curve and demand for computational and network resources [3]. As stated in recent surveys, the use of these technologies as learning environments is a new emerging trend and still under development [4,5]. While the computers and networks are constantly improving, the 3D VWs also require significant improvement to make them more convenient for educators and to deal with the steep learning curve. These facts motivate further research in the area.

In this work, we consider 3D VWs as a type of VR technology – a desktop VR. Various VR systems have a number of unique features. These technologies are becoming more affordable, and their use has been continuously increasing in recent years. They have also become more widespread as a technology for learning despite many challenges. A number of studies have been done in this area outlining advantages and limitations of these technologies as learning environments [6,7].

The main objective of the project presented in this paper is to explore the possibilities of an educational 3D VW controlled by a motion-tracking device and accessed through IPT or CAVE and a HMD.Our specific objectives are designing and developing three prototypes that would allow using vAcademia VW with the three technologies mentioned above. In particular, we are aiming at enabling vAcademia to work with and with the motion-tracking device Kinect, the ReaCTor CAVE facility, and with the HMD Oculus Rift. Such implementation may allow extending the application domains of all three systems and open additional possibilities for the VW. A research study will be conducted aiming at exploring these possibilities and defining requirements for deploying the system into practice.

Developing and evaluating three prototypes will allow testing the initial assumptions that each of the mentioned VR technologies can be applied together with an educational 3D VW and benefit learning experience. This achievement will lead to the opportunities for designing new learning and training activities for practical use and conducting further research in specific areas of interest (e.g., architecture, health care, emotions, cooperation, and logistics).

In this paper, we outline the design of the three prototypes we propose and present one of them, that implements motion tracking, in more detail. We present the design, implementation of the first prototype, evaluation results, discovered limitations, and outlined solutions. In addition, we describe the major types of learning scenarios for the use of the all three designed systems.

**Nomenclature**

| | |
|---|---|
| 3D VW | Three-dimensional Virtual Worlds |
| VR | Virtual Reality |
| SDK | Software Development Kit |
| HMD | Head-mounted display |
| CAVE | Cave Automatic Virtual Environment |
| IPT | Immersive Projection Technology |

## 2. Background and Related Work

### *2.1. Virtual Reality and Desktop Virtual Reality*

VR technology has long held promise for teaching and learning. The main arguments for their use are that 3D environments are engaging as media, and that the use of 3D rather than 2D media facilitates comprehension by the means of situating learning materials in a context, and exploiting the natural capabilities of humans to interact in 3D space [8]. Studies have shown that learning in 3D environment can provide a more effective, motivated way of learning than traditional classroom practices [9,10].

Relatively few learning simulations have been built for immersive VR, though the evidence of use in very high-value training (vehicle simulation, such as aircraft simulators or military training) is compelling. There has been extensive study of the impact of 3D immersive visualization on user behavior, lower-level task performance, and comprehension of data. A key characteristic, arguably the one that motivates the use of immersive VR in high-value training, is that participants tend to react as if the scene they were seeing were real. That is they behave in a way that is similar to their behavior in a comparable real situation [11]. This behavioral response itself distinguishes an immersive VR from other media even desktop VR, because when immersed the participant can actually act to a limited extent, as they would in the real world (e.g., by moving away from a threat). In desktop VR, this capability is limited by the form and structure of the interface.

### *2.2. vAcademia*

We propose a prototype design using a desktop VR platform vAcademia as a part of the system.vAcademiais a 3D VW that is designed for collaborative learning (http://vacademia.com/).The most distinctive feature of vAcademia is 3D recording which allows capturing everything in a given location in the VW in process, including positions of the objects, appearance and movement of the avatars, displayed media, and communication messages[12]. 3D recording is conceptually different from the video recording or screen capturing. A replayed 3D recording does not only deliver the image at any virtual camera angle and a synchronized communication messages, but contains the entire 3D scene with all objects and avatars. It can be visited by a group of avatars that can interact with each other and the recorded objects. Moreover, such a visit can be recorded again [12]. In addition, vAcademia provides a set of tools for collaborative work that can handle large amount of 2D graphical content, such as streaming and shared workspaces [13].

### *2.3. Motion-Tracking with Kinect*

Microsoft Kinect is a low-cost motion sensing input device that is able to capture one or two humans [14]. The device consists of a video camera, depth camera, and an IR camera.Low-cost motion-sensing technologies such as Microsoft Kinect, Nintendo Wii Remote, and PlayStation Move provide researchers and educators with new opportunities for improving learning experience. Multiple examples include a low-cost alternative for interactive whiteboards and multi-touch teaching stations designed based on Kinect[15].

### *2.4. Cave Automatic Virtual Environments*

CAVE is an IPT and a type of immersive VR [16]. A CAVE is typically a cube-shaped display that the user stands inside. The CAVE surrounds the user, excluding other distractions and allowing the participant to move about un-constrained. The wide field of view allows natural peripheral observation and gaze control.

ReaCTor is an example of a CAVE system, where users are wearing head trackers situated on a stereo shutter glasses. The user is surrounded by four large screens: floor, front, left and right walls. In addition, the system providesspatialized sound. Interaction with the environment is achieved using a hand tracker with joystick. Immersive VR such as CAVE-like environments have attracted industry attention in certain key industries such as for example vehicle simulation and training, scientific visualization, and psychology.

### *2.5. Head-Mounted Display Oculus Rift*

Head-mounted displayis a type of on-body VR devices that is worn on the head and has a display in front of the user's eyes [17]. Most of these devices consist of a display and a tracking system. It allows much greater immersion, as the user can control the direction of the view in a virtual world in exactly the same way as in the physical world – by turning the head. The displays of HMDs have larger field of view and provide a stereoscopic image, making the experience more believable.

The Oculus Rift (http://www.oculusvr.com/) is an HMD device that has a 7-inch diagonal viewing area and 1280 to 800 resolution split between both eyes, yielding 640 to 800 per eye [18]. A good field of view, stereoscopic vision, and fast tracking that are promised by the developers created high expectations.

## 3. Design of Prototypes

### *3.1. vAcademia-Kinect prototype*

The general motivation for designing the vAcademia-Kinect prototype is providing users of the 3D VW with a possibility to control their avatars with natural gestures. Our specific motivation for designing this system lies in making the teachers able to conduct regular lectures and presentations in the physical and in the virtual world at the same time, controlling their avatars with natural gestures.

We use two available technologies to implement the proposed system, Kinect and vAcademia. Kinect is used for capturing the movement of a lecturer (Fig. 1), while vAcademia is used for creating and recording the virtual replica of a lecture (Fig. 2). The third component of the system is a software plugin for vAcademia that translates the motion data from Kinect, the sound, and the contents of the whiteboard into the 3D VW.

Such a hybrid experience can be captured using the virtual recording feature of vAcademia. Several techniques are used by educators for getting content out of traditional classes, such as video recording of face-to-face lectures and recording of web conferences. These methods allow creating cheap educational content for asynchronous learning. 3D VWs are also used for generating such content, but learning activitiesareusually recorded as 'flat' 2D video, which eliminates many advantages of 3D VWs, such as sense of presence.

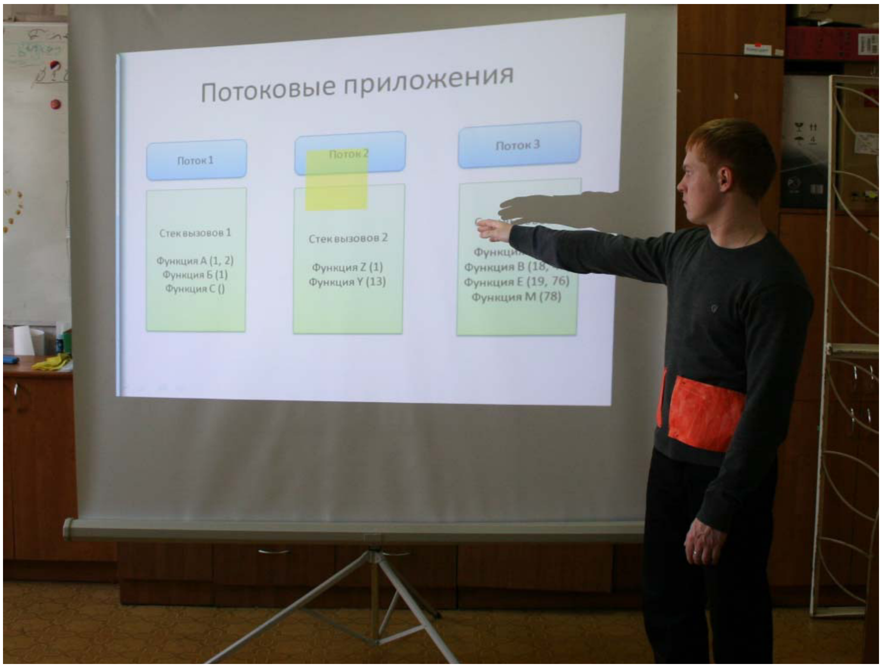


Fig. 1 Lecture capturing process

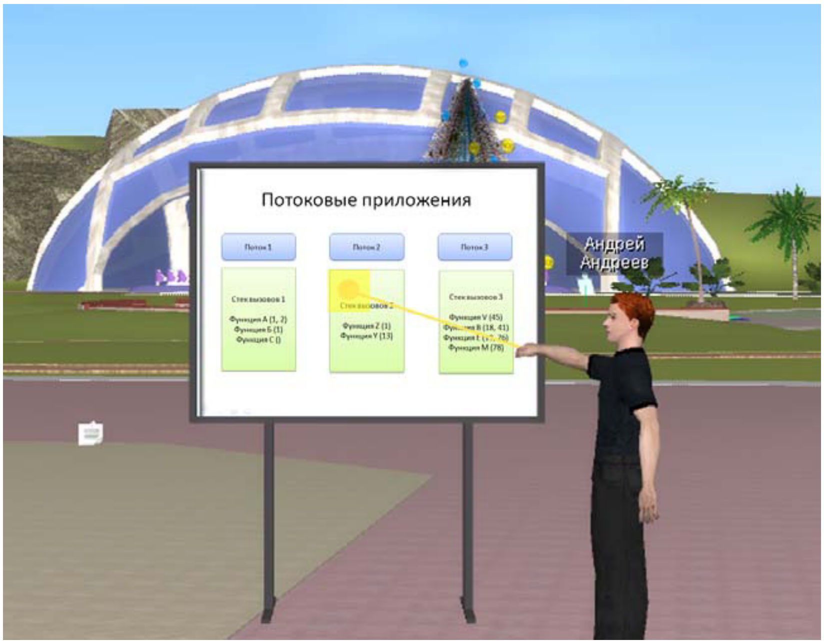


Fig. 2 Lecture streaming process

### *3.2. vAcademia-CAVE prototype*

The vAcademia-CAVE prototype is being designed should be informed by the literature review that gives evidence of the learner engagement by use of simulation in learning. We apply a theoretical framework for learning *threshold concepts*[19] in VR systems is needed to inform the systems design. In brief, the objective of system design should be to explore new ways of learning that stimulate and enhance the potential of human creativity [20]. The prototype design should consist of two development elements. First, implementation of learning scenarios and second – integration of the capability of “VR-replay” feature that is newly designed in this project to be functional between CAVE and vAcademia.

We hypothesize that using the 3D recording feature of vAcademia in the CAVE could potentially reveal patterns of becoming aware of one's own reflective learning patterns and deciding to use them consciously. Sequential interviews have been found to reveal this pattern [21]. The effect on learning of being able to replay one’s life-size avatar representation and see one’s previous actions would be investigated.

The controlled environment allows running systematically observed and tracked learning sessions. This approach will be used first to implement the scenarios. The testing of scenarios within the CAVE will allow measuring single-user experience and observing physiological responses (as indicators of engagement). This would be done for establishment of baseline measures prior to trials involving collaborative learning among several participants. Multiple participant trials would be possible by running vAcademia in CAVE, so that the participant in the CAVE would interact with other trial participants who would access the trial while using vAcademia through desktop. We would compare learning responses of participants using vAcademia on the desktop and in CAVE. In this way, key features of the threshold concept would be tested on a prototype that is a CAVE version of vAcademia. The prototype design would aim to support the ultimate objective for promoting students to overcome thresholds and enable them to identify what creativity in learning means in relation to their individual experiences in transformative processes.

### *3.3. vAcademia-Oculus Rift prototype*

The motivation for developing the vAcademia-Oculus Rift prototype is grounded in the same sources as for the one with CAVE. We are aiming at improving immersion to the virtual environment and increasing the engagement by providing a more sophisticated visual experience. However, the key differences are the higher affordability and mobility of the HMD devices, the Oculus Rift in particular.

The system will also be applied to the scenarios that are being designed for the vAcademia-CAVE prototype. However, we will conduct training sessions in multiple locations (without being restricted by a single CAVE facility we have access to) and will be able to provide multiple (or all) participants of collaborative scenarios with an immersive experience (avoiding the rigid single-user CAVE setup).

## 4. Conclusion

In this paper, we outlined the design of the three prototypes of systems that extend the immersive qualities of a 3D VW vAcademia and improve the virtual experience. We propose that using a motion-tracking device for controlling the avatar and a CAVE or HMD for perceiving the 3D environment will serve these purposes.

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